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explanation through its relation to the deeps of the North Atlantic. Oceanica may be intelligently linked up and explained.

If the establishment of isthmian connections be explicable according to the discoidal theory, can their subsequent submergence also be accounted for?—According to the discoidal theory, the source of very large masses of igneous rocks lies in the base of the discs. The extrusion of the melt is accompanied by subsidence of the central portion of the disc, which in turn and in time may be succeeded by slipping down of the elevated margins. The mechanism appears to be workable. It requires, however, fuller elaboration than can here be given to elucidate it. These concepts are obviously consistent with the permanency of oceanic basins and continental masses.

In addition to the tests proposed by these general questions, the theory should be tried by the more exacting requirements of the mechanics of deformation. This has been attempted and not without reasonably satisfactory results. The structure of the Pacific ranges of California has been discussed before the Geological Society of America and the LeConte Club of California, and the paper will shortly be offered for publication.

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[1] Abstract of a paper presented to the Geological Society of America at the Pasadena Meeting of the Cordilleran Section.

RECENT SIMULTANEOUS MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT MOUNT WILSON, CALIFORNIA, AND CALAMA, CHILE

By C. G. Abbot

Smithsonian Institution, Washington

Read before the Academy, April 29, 1919

For the past fourteen years, with the exception of the year 1907, the Smithsonian Astrophysical Observatory has observed the solar radiation at its station on Mount Wilson, California, altitude 5700 feet. Measurements are made by means of the pyrheliometer and spectro-bolometer at different hours of the day, so chosen that the intensity of the solar radiation as it would be outside the atmosphere at mean solar distance may be computed therefrom. During the earlier years of the investigation it appeared that the values found vary from day to day, as well as from year to year. In other words, it seemed to be indicated that the sun is a variable star, having a two-fold variation. First, a variation of long period, having a range of from 3% to 5% during the period of the sunspot cycle. Second, a short interval irregular variation running its course in intervals of a few days, weeks or months, and having a range often as great as 3%, sometimes as great as 7% and even in exceptional cases of 10%.

In the years 1911 and 1912, the reality of this supposed short irregular variability of the sun was tested by observing simultaneously at Mount Wilson and at Bassour, in Algeria, a station about 50 miles south of Algiers, situated at an elevation of about 3600 feet. The results of the two stations on the whole supported one another and indicated that the variations were due to causes outside the earth's atmosphere.

In the year 1918, the Smithsonian Institution sent an expedition, at the cost of the Hodgkins Fund, to Calama, Chile, to obtain during a term of years, daily measurements as far as possible of the intensity of the solar radiation. The station is situated about 150 miles northeast of Antofagasta at an elevation of 7500 feet, in one of the most cloudless regions of the world, where rainfall is almost unknown. The expedition is in charge of Mr. A. F. Moore, Director, assisted by Mr. L. H. Abbot. The observers began actual observing on July 27, and in the six months next following had observed on about 70% of the days.

During a part of this interval measurements were made on Mount Wilson by my colleague, Mr. Aldrich, and the computations have now reached such a stage of advancement that we are beginning to be able to tell that the two stations mutually support one another as to the short irregular periodicity of the sun.

In order to make a proper comparison it is evidently not necessary that the days observed should be consecutive but only that satisfactory observations should be obtained on each day of the comparison at both stations. In order to exhibit the dependence in the clearest possible manner, we may indicate Calama values by abscissae or horizontal distances, and Mount Wilson values by ordinates or vertical distances. If the measurements were without error and there was no variation of the sun, evidently all results should fall upon the same point, whether observed at one station or the other. But if there was a true variation of the sun, the point would be stretched out into a line at 45 degrees to the axes. As all measurements are subject to error it is not to be hoped that the several points corresponding to the several days of observation will all be found strictly upon such a line, but they ought to arrange themselves about it in such a way that the line will give the best mean representation.

This condition is well fulfilled. A change of 1% or less would suffice to bring almost every point on the line. Accordingly we may conclude that the spectro-bolometric determinations of the solar constant of radiation made at Mount Wilson and Calama mutually support one another and indicate a variability of the solar radiation. Since the two stations are situated in different hemispheres of the earth, separated by a distance of upwards of 5000 miles, it must be conceded that the result strongly confirms our view of the short period variability of the sun.

Investigations have already been made by Dr. Clayton and others on the correlation of terrestrial temperatures and pressures with these supposed changes in the sun, and affirmative results have been obtained by them to the question: Do the variations in the sun noticeably affect the terrestrial weather conditions? Dr. Clayton is so strongly convinced of the dependence between the weather and the solar radiation that at his desire the Argentine Government is obtaining daily telegraphic solar radiation reports from the station at Calama on which are based forecasts of the temperature in Argentina. Hitherto the correspondence has been very good, so that Dr. Clayton is very sanguine that a great improvement in forecasting will result from these solar radiation observations. The Brazilian Government has also, at his recommendation, begun comparisons.

If the further studies of the correlations between terrestrial temperatures and solar variations yield similar affirmative results, it will probably be necessary within a year or two to undertake the equipment of several additional solar radiation observing stations in the most cloudless regions of the earth. There should be not less than three additional solar radiation stations, and the cost of conducting them and the station at Calama would absorb an income of from thirty to forty thousand dollars per annum. It is to be hoped that funds for this purpose may become available to the Smithsonian Institution, for with the experience gained by the staff of the Institution it would be able to carry on the research in a way to obtain homogeneous and accurate results.

The choice of sites for additional solar radiation stations involves investigation as to the most cloudless regions of the earth. None of the stations hitherto occupied, not even that at Calama, is as satisfactory as we could wish for. The most serious enemy to the research is the presence of cirrus clouds, or any other form of cloudiness, and it is a grave problem where in the world these are least numerous. The comparison of the observations at the two stations in 1918 shows that no inconsiderable number of the days in which observations were made were unsuitable for the purpose on account of the changes of the atmospheric transparency during the two or three hours necessary to the determination. It is this defect of the uniformity of the atmospheric transparency which requires us to make the measurements at so many stations in order to get a satisfactory result.

Both the Mount Wilson and Calama observations indicate that the solar radiation was above its normal in the year 1918, having an average value of about 1.95 calories per square centimeter per minute. The mean value for many years was 1.93.

ROTATING PROJECTILES FROM SMOOTH-BORE GUNS

By C. G. Abbot

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Read before the Academy, April 29, 1919

In the late war much use was made of trench mortars. This kind of ordnance consists essentially of a smooth tube with a firing pin at the bottom. The projectile carries a shotgun shell at the rear. It is dropped down the smooth-bore barrel by the soldier and the firing pin explodes the primer on the shotgun shell. This in its turn explodes the charge of propellant which throws the shell into the enemy's lines. Many of the trench mortar shells tumbled end over end as they went over, but some were provided with fins which retained them in approximately steady flight. However the trajectory of these shells was by no means ideal.

It occurred to me to try to secure sufficient rotation to produce steady flight by means of the turbine principle applied to the shells. Unfortunately the research was proposed to me only a few days before the armistice was declared so that by the time preliminary tests were made it was too late for the device to be of war service. However, the results appeared to be so promising that I have made numerous further experiments with a smooth-bore musket of 0.9 inch diameter which had seen service in the Civil War.

The elongated ojival projectile was made in two parts in my experiments, the one a tough steel rear part chambered out to contain the propellant, the other an aluminum nose provided with a steel plug at the rear for screwing into the steel part of the projectile. The steel plug serves the double purpose of closing the chamber and attaching it to the front part. With the aluminium part in front such projectiles are particularly well calculated for tumbling, and invariably did so when fired in the usual manner. At the extreme rear of the steel part of the